Scaling the Java™ Technology Environment in Four Dimensions

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Session TS-3625

Goal of This Talk

Learn how to identify and refer to services that may change their location over time, as a first step to building long-lived systems

Agenda

Setting the Stage

Current Remote References

Sketch of the Solution

Extensible Pure Names

A UuidDirectory

Refreshable References

In Conclusion

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The Driving Application

Medical sensing

- Suppose you could
  - Place medical sensors on everyone
  - Record the information all the time
- We have the sensor technology
- We have the network infrastructure
- We don't have the back-end technology

A Multi-Purpose Infrastructure

- Practicing physicians
  - Allow better diagnosis
  - Enable triage at a distance
- Public health
  - Real-time monitoring
- Research
  - A rich data set for longitudinal studies

Such a System Would Require

- A distributed solution
  - Nothing else could scale
  - Nothing else would give appropriate security
- A reliable solution
- A federated solution
  - There is not central medical authority
- A long-lived solution
  - Data needs to last as long as the patients

Building an 80 Year System

- Every part of the system will be replaced
  - Often more than once
- Services will evolve
- Information will change
- Services will move
  - To balance load
  - As machines are replaced

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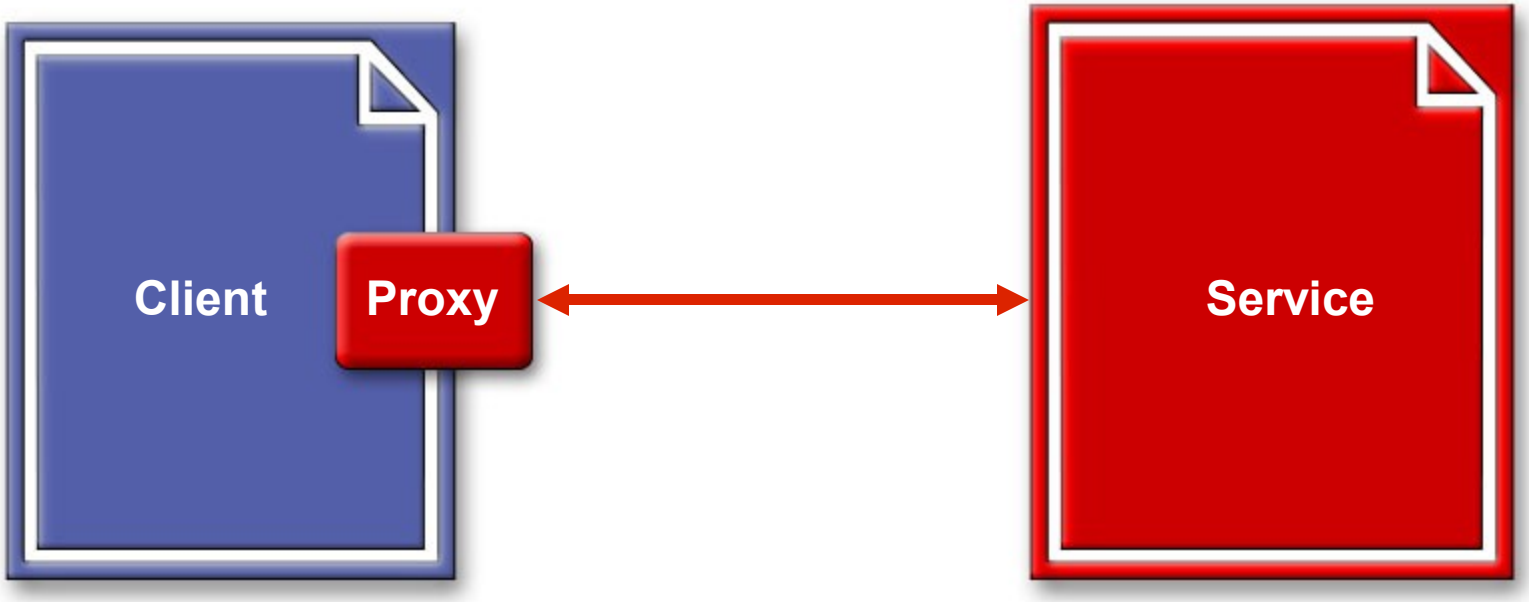
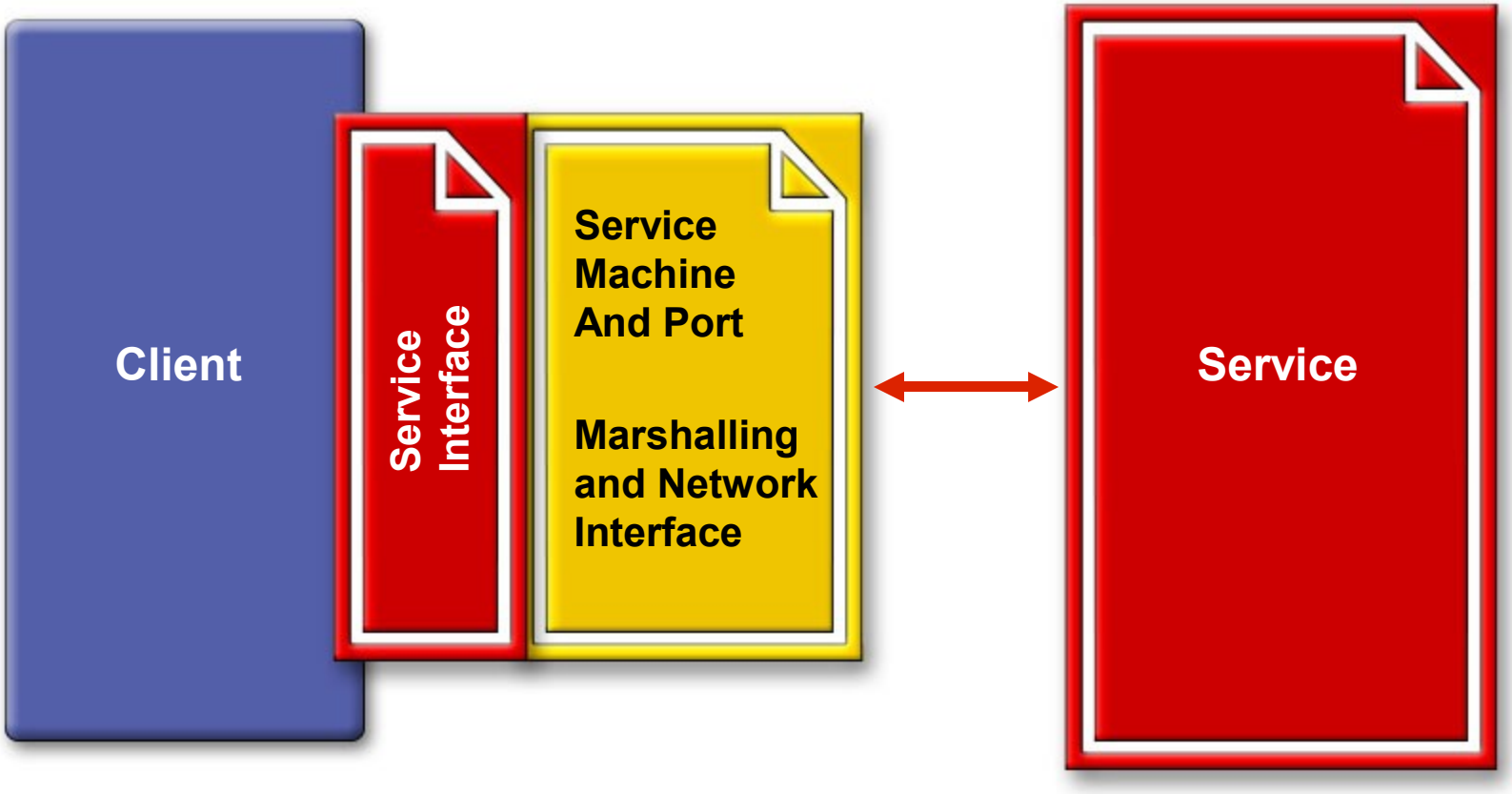
A Remote Reference

- Supports a service interface
- Contains location information
  - The machine where the server is
  - The port where the server is listening
  - The machine and port that knows where the server is
- This is true of
  - Java Remote Method Invocation (RMI)
  - CORBA
  - Jini™ Extensible Remote Invocation

The Big Picture



Somewhat More Detail



When a Service Moves

- The reference points to the wrong machine
- We could leave a tombstone
  - Tombstones forward from old location to new
  - But what if the machine is gone?
- We could require all references to be replaced
  - Inefficient
  - How do we insure we get the same service?

What About Using Names?

All problems can be solved with an extra indirection

- Identify a service by a name
  - Provide a naming service
  - When a service moves, get a new proxy by name
- Usual names are hierarchical
  - Local scope allows guaranteed uniqueness
  - Hierarchy enables scale
- But hierarchies introduce location
  - Movement assumes no location

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A Different Kind of Naming

Pure names

- A pure name can only be used
  - To compare for equality
  - To identify an object
- Also known as Universally Unique Identifiers
- There are multiple instantiations
  - **`java.util.UUID`**
  - IETF draft
  - Home-grown (patient identifiers)
- How to federate?

A Different Kind of Naming Service

How can we scale a flat namespace?

- Usually name services scale with
  - Local name service
  - Hierarchy based on name
  - Traverse lookup hierarchy from name hierarchy
- Pure names have no hierarchy
- Use distributed hash tables
  - Partition name space arbitrarily
  - Connect naming services

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Pure Name Requirements

One approach does not fit all

- Identifiers must be
  - Unique (to what level of confidence?)
  - Comparable
  - Allow mapping to existing identifiers
- The base intuition
  - Make part of the identifier how it was generated
  - Allow (but not require) global disambiguation

Xuid Interface

```
Interface Xuid {
    public long getGeneratorId();
    public byte[] getId();
}

// any class implementing this will need to implement
// equals() and hashcode() so that
// a.equals(b) iff a and b have the same GeneratorId and
// the byte array of the rest of the Xuid is byte-for-byte
// the same
```

Xuid Layout

A two-part universally unique identifier, first part

- The GeneratorId
  - If registered with a global authority
    - First two bits are 0
    - Next 62 bits are guaranteed unique by the authority
  - Otherwise
    - First 64 bits are a secure hash of the generation code
- There may not be a central authority
- Two unregistered generators will be equal
  - Only if the generation code is identical
  - Which is what we want

Xuid Layout

A two-part universally unique identifier, second part

- The Id
  - A byte array
    - Different generators may produce different sizes
    - Generators are responsible for uniqueness
- Identity comparisons
  - Should check generator Id first
  - If those are the same, byte length should be the same
- Hashing
  - Combine generator and bytes

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XuidDirectory Interface

```
Interface UuidDirectory
{
    Lease register(Xuid id, Object o, long leaselen)
                throws UnknownXuidException,
                       RemoteException;

    Lease[] register (Xuid[] ids, Object[] o,
                        long[] leaseLens)
                throws UnknownXuidException,
                       RemoteException;

    Object lookup(Xuid id, XuidDirectory[] visited)
                throws UnknownXuidException,
                       RemoteException;
}
```

Xuid Directories

- Registration
  - Of single objects
  - Of groups of objects
  - Objects responsible for their own registration
- All registrations are leased
  - Bounded time failure determination
- `XuidDirectory` objects can
  - Consult other directories
  - Split and join
  - `Lookup` needs to know where it has been

Xuid Directories as DHTs

- Distributed Hash Tables
  - Partition the space of a hash
  - Dynamically split and join
  - Have failure recovery mechanisms
- A good fit for Xuid Directories
  - Flat namespace
  - Excellent scaling properties
- Peer-to-peer properties
  - Allow merging disjoint directories on discovery
  - A first step at federation

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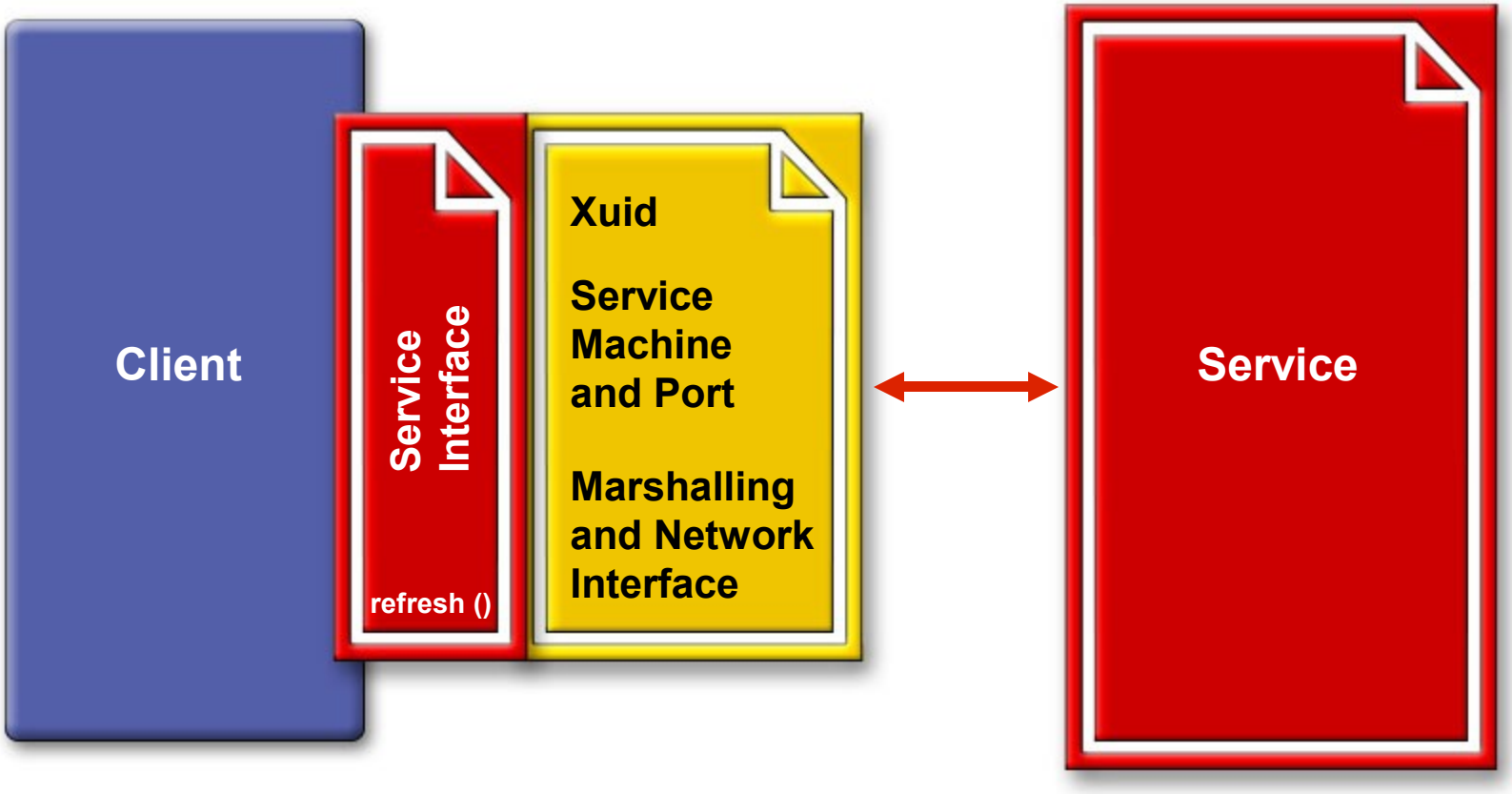
Refreshable References

```
Interface BasicRef
{
    Xuid getXuid();
    Object refreshProxy(XuidDirectory[] hints)
              throws UnknownXuidException,
                     RemoteException;
}
```

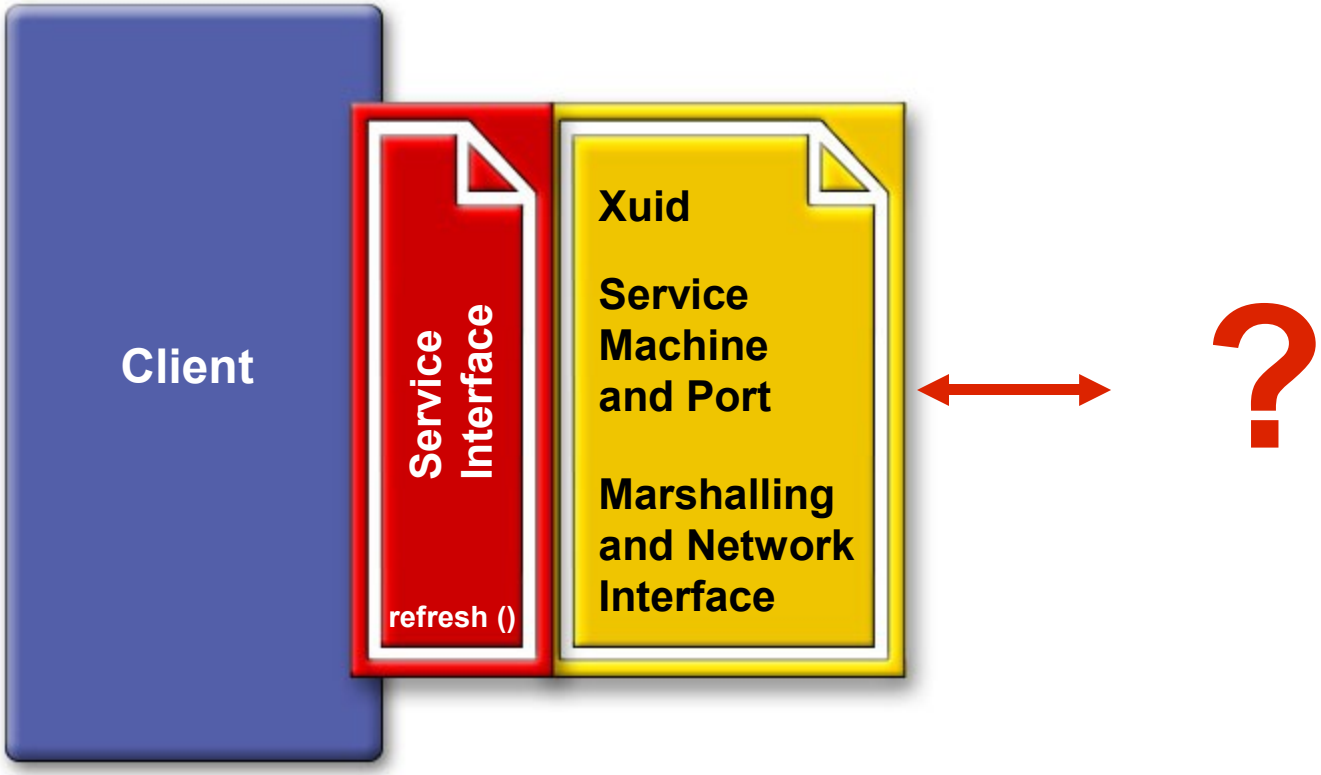
References to Moveable Objects

- Implement BasicRef
  - Need an Xuid
  - Implement a refresh method
- On receiving an exception, the client
  - Calls refresh()
  - Can supply local directories
  - Casts the result to the right type
  - Discards the old reference
  - Can continue

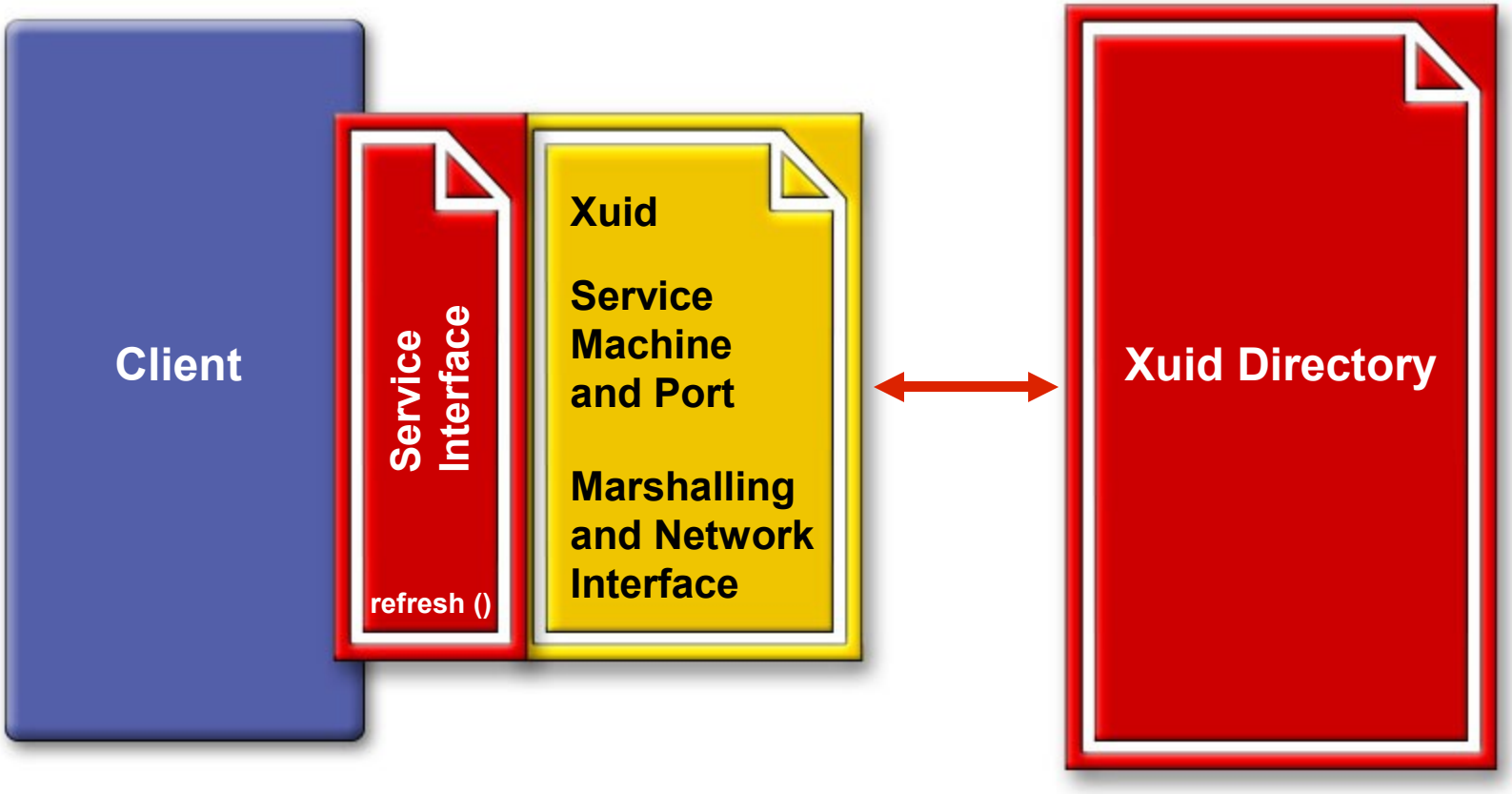
Somewhat More Detail (Revisited)



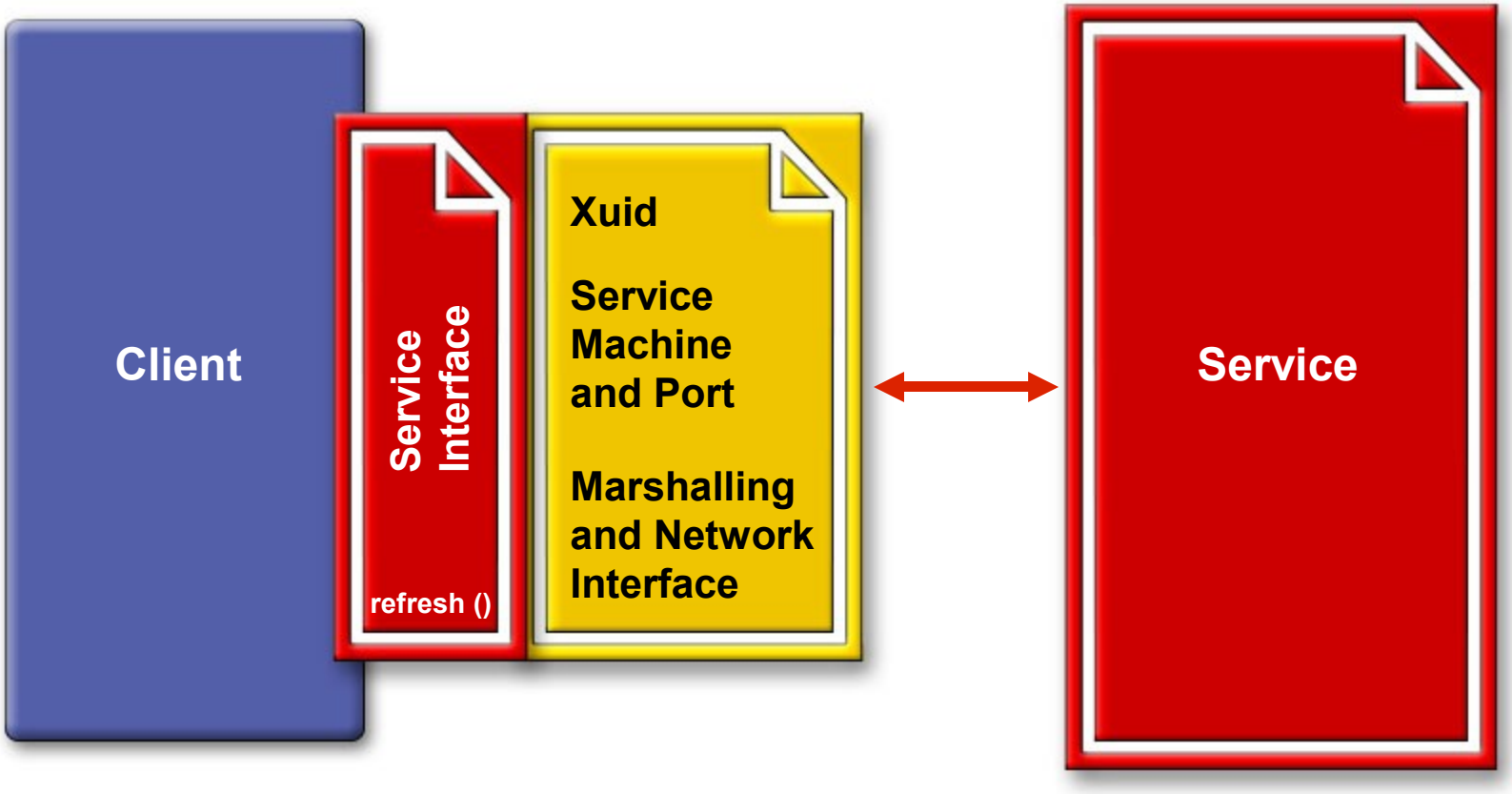
When the Service Moves



Use the Xuid Directory



Use the New Reference



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Services Can Move

But still might get lost

- Xuids give
  - Pure names with no presumed location
  - Uniqueness tied to the way they are generated
- Xuid directories allow
  - Moved objects to re-register
  - Refreshable proxies to find the new location
- But things can still fail
  - Service might just be gone
  - May have moved to an inaccessible Xuid Directory

Just a First Step

There is lots more to do

- Security model
  - Need to insure security and privacy
  - But medicine has a different model
- More than location will change
  - There will be new sensor/data types
  - There will be new languages
  - There will be new things that we can't conceive
- But this is research
  - Which entails that we don't know what we are doing

Q&A

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